A SIMULATION MODEL OF THE IBM 360 COMPUTER IN AN MVT ENVIRONMENT

by

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UNITED STATES
NAVAL POSTGRADUATE SCHOOL

THESIS

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ABSTRACT

This paper reports on the design of a computer simulation model written in GPSS. A brief description of the System/360 operating system is given. The model consists of macroscopic modules representing distinguishable computer tasks which are capable of independent operation and/or more detailed expansion. A pseudo jobstream of sufficient detail was used to test the viability of this model. Guidelines for experimentation (which was prohibited by a complete lack of data) are outlined; suggested uses of the model are given.

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CHAPTER I

I. INTRODUCTION

A well designed simulation model can effectively predict system performance under a variety of conditions for a relatively low cost. This efficiency becomes an even more important tool when the system is an expensive computer where even subtle changes are costly in time and money. Such a model has been constructed for the IBM 360/67-2 recently acquired by the U.S. Naval Postgraduate School: it is basically macroscopic in design, although facilities have been provided throughout for refinement of statistics at the microscopic level. It depicts operation utilizing the IBM Operating System/360 in an MVT environment. The model developed allows one to analyze an existing system or test proposed configurations.

A. BACKGROUND

Since the arrival at the school of the System/360, the system implementation and operation has been based on the recommendations provided by IBM engineers and literature, and those of the school's staff of system programmers. Although the operation has continually improved over the past eighteen months, it has been at no small expense to the users; system configuration and development experiments have been performed with the normal jobstream.

The users consist of students, staff and faculty in varying percentages, dependent on the time of year. Student usage consists of beginning FORTRAN programmers, Computer Science students engaged in advanced and systems programming, and thesis students. The staff work is devoted to maintenance of academic records and schedules, and such operations as the student text and classified document libraries. Faculty utilization is by computer class instructors and those engaged in research projects. The computer staff's applications and systems programmers are, of course, utilizing the facility. With few exceptions, all users are in equal competition for the use of the computer, and at no expense to the individual except for his time. It is not unusual to find the backlog of jobs waiting to be processed in excess of twenty-four hours at the peak period of the quarter.

Although work is now in progress on a comprehensive accounting system, timing data on the jobstream is not presently available. The information needed to properly design the priority scheduling algorithm, necessary for efficient machine utilization, is also unavailable.

Except for WATFOR batch runs and a few other jobs handled on an individual basis, the jobs are run on a first-in-first-out basis. This results in lengthy turnaround, much operator time spent in the mounting and dismounting of special disk packs, and an occasional system lockup when a job with unusually large requirements unexpectedly enters what might already be an overtasked system environment.

The possibility of the addition of equipment (core and direct access facilities) to improve overall performance and the reconfiguration or elimination of present machinery is ever present.

B. DEFINITION OF THE PROBLEM

This paper discusses the design of a simulation model of the 360's Operating System in an MVT environment on a model 67-2 machine. When jobstream statistics are provided, the simulation model is designed to predict system performance with a degree of accuracy necessary for planning and evaluation purposes. By the manipulation of certain parameters and/or blocks, the model may be made to conform to a variety of configurations and scheduling schemes.

No data concerning the actual jobstream has been collected at the school as of this time, except for a manual count of the number of jobs run on a given day. This lack of information prohibits the use of comparative experimentation to validate the model other than at the most fundamental level. Comments concerning this phase of model development will therefore be restricted to a discussion of the techniques which should be used in experimentation when job data becomes available.

Validation of this model was conducted by applying a pseudo jobstream, which is described in detail in Chapter III, to the model and conducting a parametric analysis of the important aspects of all modules. In addition, these results were compared with the author's observations of the actual processing of similar jobs on the 360.

The conclusions drawn will necessarily be concerned only with the viability of the developed model.

CHAPTER II

SYSTEM DESIGN

The System/360 consists of numerous hardware devices and an operating system. A thorough knowledge of both these areas was a prerequisite to the development of this simulation model. This information is available from numerous I.B.M. publications; those referenced are thought to be representative and give a broad enough background for an understanding of the model.

The configuration discussed here consists primarily of 2 central processing units (CPU's), 512K bytes of main storage, 1 drum and 8 disk storage devices, 4 tape units, 2 card readers, 2 printers, a card punch, 12 communication terminals, a graphical display unit, 2 graphical plotters, and associated channel control units. These are all interconnected through a switching device which allows many configurations including separate, simultaneous processing by the 2 CPU's (9). Although the hardware can be utilized to support multi-processing, the MVT Operating System does not provide these capabilities; hence, only mono-processing is considered in the model. Five methods are provided for interruption of the CPU (program, supervisor call, external, I/O, and machine check).(8)

The operating system is responsible for satisfying valid user request through proper job, task, and data management (5). The flow of system responces and user requests is shown in Appendix A. Job management in MVT handles scheduling on a priority basis, interprets the user requirements, assigns devices, and initiates and terminates each job step. Task management includes resource allocation, and task supervision. Data management concerns itself with label processing, retrieval of data sets, buffer management and scheduling, and data set access (7).

An MVT environment is one which allows several tasks to be simultaneously in core storage. Input readers, output writers, several user jobs, resident routines, and operator communications routines can all be in core at the same time, subject only to storage limitations. The various tasks compete on a priority basis for the CPU; interrupt handling procedures include switching to the highest ready task when appropriate. Thus simultaneous job processing and I/O operations are possible with this multitasking situation (10,11).

A job presented to the computer is thus read into the queue of jobs awaiting processing by a reader/interpreter task, executed by an initiator/terminator task, and has its output processed by one or more writer tasks. The possible advantages of multitasking in terms of efficient equipment utilization are apparent; however, the analysis of such a system seems only tractable by means of simulation techniques. Available analytical techniques (14) require simplifying assumptions unrealistic for modeling a complex system such as MVT.

CHAPTER III

I. MODEL DESIGN

A. GENERAL

It is possible to model every individual operation of a computer system including hardware, control program, and jobstream in an exact manner. Such a simulation, when applied to multiprogramming situations will result in a cumbersome model which requires as much or more running time as the actual operation. It is the objective of this study to provide a simple model whose behavior is representative of that of the real system. At the same time it is necessary to provide expansion points for future study and model refinement. Thus a complex operation may be represented by a simple delaying "advance" block (2); if it is necessary to examine that facility more closely, the single block could be replaced with a series of detail blocks which more accurately approximate the operation.

The ease with which various sub-systems could be constructed from block diagrams and the provisions for handling interupts of transactions on a priority basis led to the choice of GPSS/360 for implementation of the model. Certain simplifications of the model were necessary to accommodate language restrictions or those imposed by the demands of processing time.

The model reflects the configuration of the IBM 360 model 67-2 computer operated at the U.S. Naval Postgraduate School under release 14 of the Operating System generated for option 4, Multiprogramming with a Variable number of tasks. It is expected that minor modifications of the model will be required for its application to subsequent versions of the MVT operating systems.

B. JOBSTREAM GENERATOR

The jobstream generator module was designed for the purpose of exercising the model only; it must be replaced in order to obtain useful experimental results. Each jobstep is represented by a transaction which is created by a generate block. The job and step attributes are represented by the values of parameters associated with each transaction as indicated in Table 1.

Parameter	Description
PR	The job's PRTY parameter initially, and subsequently its dispatching priority during execution
P1	Varies; used for communication between modules
P2	Number of steps in the job
P3	Number of input records (cards)
P4	Number of Class A output records (print)
P5	Size of REGION required in K (1024 bytes)
P6	Execution time (CPU) in milli-seconds
P7	Mean CPU time between interrupts
P8	Number of Class B records (punch)
P12	Initiator being utilized during execution

Table 1. Parameter Association for Jobstream Generator

The present jobstream consists of identical one step jobs. The parameters were chosen to be representative of an average student job which exercised all modules of the model. The selected parameters are shown in Table 2.

Parameter	Value	Meaning
PR	8	Selection Priority
P2	1	Number of steps
P3	100	Number of input cards
P4	2500	Number of lines of print
P5	100	Region size
P6	30000	Execution time in milli-seconds
P7	100	Milli-seconds between interrupts
P8	10	Number of output cards

Table 2. Parameter Values for Pseudo Jobstream

The priority of eight is the present default priority at the school. Execution time, region size, input cards, and output lines and cards are about average for a student job. The time between interrupts was an arbitrary number used to test the interrupt mechanism.

C. READER/INTERPRETER

The reader/interpreter module enters the jobstream into the system jobqueue and input spools. Those jobs which are marked as having job control language errors are processed in a "jobfail" mode. Default parameters are not provided by the reader for jobs as this was thought to be a simple external task and would degrade the operation of the module. Each job step transaction must therefore be presented to the reader with all required parameters supplied.

The module will operate multiple input streams if desired, each of which needs 42K of core. The starting and stopping of readers is controlled by the contents of the jobqueue. Processing time for each job is dependent upon the number of steps and the number of cards read. To operate the model the reading rate was assumed to be 1000 cards per minute, the maximum speed of the 2540 card reader. Since the reader/interpreter does not always operate this rapidly, modification should be made when timing information is available. The formula used for the number of spooling tracks needed, (P3/401+1)10 is based on the 2311 disk drive's track capacity and the present default of 10 tracks per extent.

D. OUTPUT WRITER

The system output writers handle all final output associated with each job and the purging of the job from the simulation. Multiple output devices are supported; each requires 28K of core. The class B (punched) output is allowed to back-up to a given level before it is punched; and then it operates until the queue is empty. The class A (printed) output writer operates for the entire simulation run unless it is redefined between start control cards. A start-stop system similar to that devised for the punch could be applied to the printers if desired. Processing time required for the writer is dependent on the number of records produced by the job and the speed of the output device. The use of special characters which slow the processing time were not considered in this model. It is felt that this situation would best be handled by providing a separate class for this type of output. The output formulas P4/27+1 and P8/42+1 for class A and B outputs respectively are based on the track capacity of the disks. The print speed was set at 1200 lines per minute.

E. IPL

The IPL module conducts the Initial Program Load by defining the systems configuration parameters for the simulation run. The IPL transaction enters core in the amount of the nucleus/system queue area plus the link pack/master scheduler area. It starts the appropriate number of readers, initiators, and writers, then moves to the start-stop loops where it operates for the remainder of the simulation. This module is provided to allow simulation of system restart, as well as a convenient and realistic method for specifications of system parameters.

F. INITIATOR/TERMINATOR

The initiator/terminator provides the processing support for the jobstream. The job, once having entered the initiator, is processed by the ENQ routine. It was felt that the enqueing of resources was not of particular significance at this installation since the majority of users enqueue only on sharable resources, such as the system disks, spools, and program libraries. The routine is branched to, however, in order to provide for expansion if necessary. The initiator then assumes the dispatching priority of the job and obtains core space (REGION) for it. The model does not ensure that this region is of contiguous core due to the characteristics of the 'storage' block in GPSS; this occasionally allows a job to be processed which would normally be delayed due to core fragmentation (2). Proper operator technique and job classification minimizes the possibility of core fragmentation on the real system; hence, this discrepancy is not considered to unduly affect the model.

Device allocation is handled by the allocate routine which assigns devices to each job step which requires non-temporary data sets on direct access or tape storage. Experience thus far with the actual system operation[1] has shown that temporary storage space is not a problem with the amount of spooling space provided, hence it is not considered here. If the number of spools should be reduced, this problem might bear closer examination. Private disk pack allocation is handled along the lines of present day usage of such job libraries. Since the policy regarding the use of such disks may well change in the future, this portion of the model should be made to conform with the policy imposed. There are presently four spools and two private library drives in both the actual system and the model.

The transaction is next released to process until completion. The CPU facility is preempted on a priority basis and a copy transaction is split off and acts as an interrupt for that step during processing. When the execution time parameter has been reduced to zero, the step is considered completed and the termination process is entered in order that devices may be freed and region released. If there are further steps, they now enter the initiation phase at the device allocation level and are similarly processed. If the previous job step was abnormally terminated, as indicated by an initial value of zero for the execution parameter, the following steps are "flushed". The last job step is routed through the DEQ routine following termination, indicating

---

[1] The author was able to obtain several listings of the Volume Table of Contents (VTOC) on each of the spooling disk packs at different intervals including periods of peak spooling activity. At no time did these volumes exceed 50% of their combined capacity.

job termination and releasing the initiator to select a new job.

G. INTERRUPTS

Only those interrupts which require task switching, i.e., those which place the current task in a wait state, are considered. This was done because other types of interrupts are already included in the job execution time. To include these would require more simulation time, complicate the model, and add little to the results. At random times during the processing (the distribution is determined by the interrupt parameters of the job step) these interrupts preempt the CPU and place the current task in a wait state; this is followed by interrupt processing time and the initiation of parallel I/O processing. Upon completion of post-I/O processing, the task is placed in a wait state and allowed to compete for the CPU facility. The buffer capability of GPSS which restarts the scan of transactions to dispatch that one which possesses the highest priority is used for task switching purposes.

H. I/O

Although facilities have been provided for channels, control units, and device units, little I/O operation is simulated due to the time consuming complexity of the operation. These operations are represented rather well by simple advance blocks with times provided from standard distributions. If the area of I/O operation is found to be of interest and statistics from the actual system can be gathered, this module may be expanded to handle I/O with greater accuracy. The formulas in Table 3 are provided for computation of Channel and Control Unit facility given the unit facility number (F).

Actual	Model
Channel 0 (F=21...84)	8
Control Unit	(F+111)/12
Channel 1 (F=85)	9
Control Unit	17
Channel 2 (F=86...97)	10
Control Unit	(F-14)/4

Table 3. Channel and Control Unit Calculation Formulas

Individual unit assignments are listed in Appendix B.

As an example the model card punch is facility 47 (F=47). Since F is less than 85 the actual Channel is 0 (model facility 8). The Control unit is the least integer in (47+111)/18=13. These formulas should be used for rapid calculation in I/O operations.

I. PRIORITY

Transaction priorities are limited by GPSS to values between 0 and 127, whereas those in the actual system range from 0 to 255; therefore the model uses numbers equal to one half of those used in the actual system (rounded down to the nearest integer), to represent priorities.

CHAPTER IV

I. RESOLUTION

A. RESULTS

As there was no data available concerning jobstream characteristics, measurements on hardware utilization, or processor utilization by system tasks (overhead), the validating results are from model operations with the pseudo jobstream only. The runs were made with the parameters described in Chapter III and from one to three initiators. Statistics were gathered after three and six simulated hours. During the first hour, job generation only was done to provide an initial backlog. It was intended that the results be realistic and not necessarily accurate due to the complete lack of accurate input statistics. The results obtained are summarized in Table 4.

Statistic	1 Initiator		2 Initiators		3 Initiators	
	3 hrs	6 hrs	3 hrs	6 hrs	3 hrs	6 hrs
Jobs Generated	184	361	184	361	184	361
Jobs Read	71	71	71	168	113	184
Jobs Executed	21	54	42	108	63	162
Jobs Printed	21	54	42	108	63	162
Jobs Punched	21	42	42	105	63	147
Average CPU Utilization	.060	.077	.121	.151	.182	.227
Average Core Utilization	.039	.320	.439	.549	.561	.701
Average Spool Utilization	.055	.058	.065	.070	.056	.080

Table 4. Sample Results from Pseudo Jobstream Runs

As expected, the amount of work accomplished was related to the number of initiators in operation. Resource utilization also increased as expected. The CPU utilization is much lower than actual since the system overhead has not yet been incorporated. Intermittent punch and reader operation based on queue sizes account for the differences in these figures and the increase in the number of jobs read. Other statistical output from these runs and a run of twenty-four hour duration gave similar results. In each case this data supports the viability of the model.

The actual running time of the model was a function of the number of transactions and the number of blocks in the system, with the former being by far the greatest factor. When transactions were changed from their representation as a job step to that of a complete job, the time was decreased by more than a factor of three. Exact figures for model timing are not available due to the absence of an accounting routine on the present system. The use of link chains, where possible, was also found to improve efficiency. The elimination of blocks which added little to the model due to their infrequent use or infinitesimal contribution to the delaying time of a transaction enabled a much larger sample of jobs to be completed in this same amount of computer time.

B. RECOMMENDATIONS

When accurate operational data is made available, thorough experimentation must be conducted to completely validate the model. These experiments should show that the model is an accurate representation of the system in every area which is to be studied by the use of this simulation model. A jobstream should be chosen which depicts a wide variety of jobs representative of those presented to the computer facility for processing. Data must then be gathered from actually running this jobstream and comparisons made with the statistical output of the GPSS simulation of the same jobstream. Direct comparisons should then be made of all queue sizes, taks processing times, resource utilization, and total tasks processed. Care must be taken that jobs are run under the same configuration and parameter (number of initiators, readers, writers, etc.) circumstances and that observation intervals are the same for both system and model.

Provided these experimental results show the model to be valid, it may be utilized in several capacities. Individual parameters should be varied to determine optimum operational methods. New modules may be added to test the efficiency of adding new equipment. Configuration may be varied to determine optimal equipment mixes. The jobstream can be modified to find better means of job classification. Measurements can be made at points in the model which are unavailable or difficult to obtain from the system. In any case, best results will be obtained if all sections except the one being studied are left unchanged at first. Secondary experimentation to study interaction effects should then be undertaken.

C. CONCLUDING REMARKS

To be effective the model must be simple. Only those portions of the simulation which are to be studied should be expanded in detail. A bulky model results in clouded results and becomes as time consuming as the system itself.

The results will be no better than the statistical information upon which it is based. Knowledge of the actual jobstream is therefore of utmost importance, followed closely by machine timing information. With this data available for a base, sound predictions concerning new methods may be obtained.

CHAPTER V

SUMMARY

This paper reports on the design of a simulation model of the IBM 360 Computer operating in a Multi-programming with a Variable Number of Tasks (MVT) environment. The design is based on the operating system and computing equipment available at the U.S. Naval Postgraduate School's Computer Facility.

The model is written in the General Purpose Simulation System/ 360 (GPSS) language and is basically macroscopic in design. Each portion of the model can operate separately or be expanded in greater detail to allow for closer study of that particular aspect of operation.

A brief outline of the System/360 is given; included is a description of the hardware components, responsibilities of the operating system, elements of the MVT environment, and further system references.

There are seven major operational modules: a test jobstream generator; reader/interpreter; interruptor; and input/output. Also provided are an exponential function, commonly used variables, a clock, and a run control section.

Since jobstream, timing, and overhead data were not available from the facility, the model was operated using a pseudo jobstream for testing purposes. The results of the experiment were as anticipated and showed the model to be viable. It was also found that the efficiency of the model was enhanced by reducing the number of transactions to a minimum and by simplifying operations to only a few of the more important and/or time consuming steps.

The full validation of the model requires the utilization of presently unavailable system and jobstream timing information; an outline of the required validation trials is included. Model utilization is described with the stipulation that the verifying simulation tests are favorable.

It is concluded that simple models operate more efficiently and that many system and jobstream statistics must be known for effective model operation.

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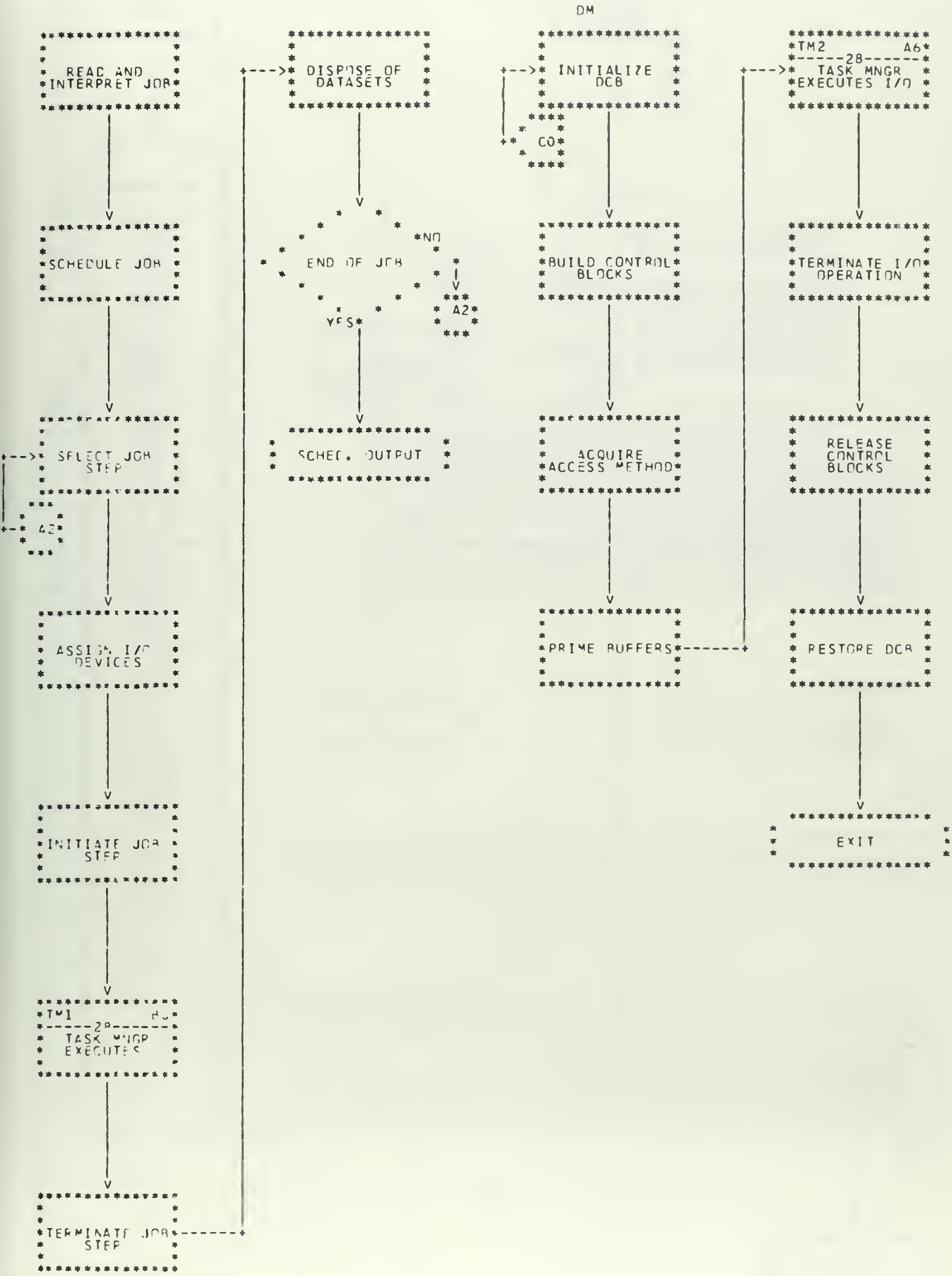
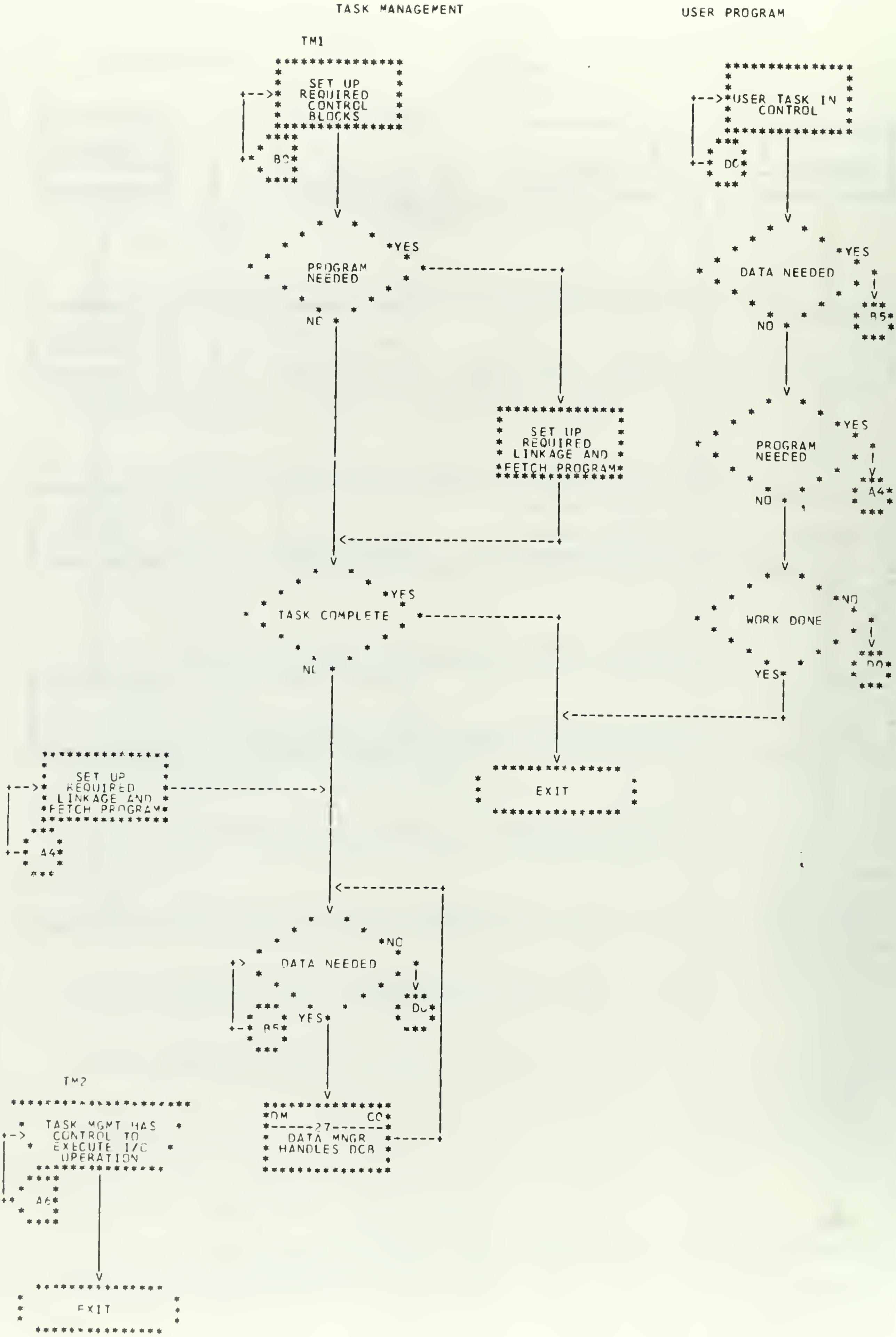
APPENDIX A

JOB MANAGEMENT DATA MANAGEMENT




TASK MANAGEMENT
USER PROGRAM
TM1
SET UP REQUIRED CONTROL BLOCKS
B2
PROGRAM NEEDED
YES
NO
SET UP REQUIRED LINKAGE AND FETCH PROGRAM
TASK COMPLETE
YES
NO
SET UP REQUIRED LINKAGE AND FETCH PROGRAM
A4
DATA NEEDED
NO
YES
B5
DM
CO
27
DATA MNGR HANDLES DCB
EXIT
USER TASK IN CONTROL
D0
DATA NEEDED
YES
NO
B5
PROGRAM NEEDED
YES
NO
A4
WORK DONE
NO
YES
D0
TM2
TASK MGMT HAS CONTROL TO EXECUTE I/O OPERATION
A6
EXIT

APPENDIX B

```
*****************************************************************************
*                                                                           *
*                                                                           *
*      A SIMULATION MODEL OF THE IBM/360 COMPUTER, US NAVAL POST-          *
*   GRADUATE SCHOOL, MONTEREY, CALIFORNIA, IN A MULTI-PROGRAMMING          *
*   WITH A VARIABLE NUMBER OF TASKS ENVIRONMENT.                           *
*                                                                           *
*                                                                           *
*****************************************************************************
*
*     EQUATES
*
INIT1  EQU        1,F
INIT2  EQU        2,F
INIT3  EQU        3,F
INIT4  EQU        4,F
INIT5  EQU        5,F
CHA0   EQU        8,F                    CHANNEL ZERO
CHA1   EQU        9,F                    CHANNEL ONE
CHA2   EQU        10,F                   CHANNEL TWO
UCT00  EQU        11,F                   UNIT CONTROLLER ZERO ZERO
UCN01  EQU        12,F                   UNIT CONTROLLER ZERO ONE
UCN03  EQU        13,F                   UNIT CONTROLLER ZERO THREE
UCN07  EQU        14,F                   UNIT CONTROLLER ZERO SEVEN
UCN0B  EQU        15,F                   UNIT CONTROLLER ZERO B
UCN0C  EQU        16,F                   UNIT CONTROLLER ZERO C
UCN10  EQU        17,F                   UNIT CONTROLLER ONE ZERO
UCN20  EQU        18,F                   UNIT CONTROLLER TWO ZERO
UCN27  EQU        19,F                   UNIT CONTROLLER TWO SEVEN
UCN29  EQU        20,F                   UNIT CONTROLLER TWO NINE
CON09  EQU        21,F                   CONSOLE TYPEWRITER 009
PLT0F  EQU        22,F                   PLOTTERS 00F
TRM11  EQU        33,F                   COMMUNICATIONS TERMINAL 011
TRM12  EQU        34,F                   COMMUNICATIONS TERMINAL 012
TRM13  EQU        35,F                   COMMUNICATIONS TERMINAL 013
TRM14  EQU        36,F                   COMMUNICATIONS TERMINAL 014
TRM15  EQU        37,F                   COMMUNICATIONS TERMINAL 015
TRM16  EQU        38,F                   COMMUNICATIONS TERMINAL 016
TRM17  EQU        39,F                   COMMUNICATIONS TERMINAL 017
TRM18  EQU        40,F                   COMMUNICATIONS TERMINAL 018
TRM19  EQU        41,F                   COMMUNICATIONS TERMINAL 019
TRM1A  EQU        42,F                   COMMUNICATIONS TERMINAL 01A
TRM1B  EQU        43,F                   COMMUNICATIONS TERMINAL 01B
TRM1C  EQU        44,F                   COMMUNICATIONS TERMINAL 01C
PTR30  EQU        45,F                   PRINTER 030
RDR31  EQU        46,F                   READER 031
PUN32  EQU        47,F                   PUNCH 032
PTR70  EQU        57,F                   PRINTER 070
```

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RDRBO EQU       69,F                  READER OBO
TAPCO EQU       81,F                  SEVEN TRACK TAPE OCO
TAPC1 EQU       82,F                  NINE TRACK TAPE OC1
TAPC2 EQU       83,F                  NINE TRACK TAPE OC2
TAPC3 EQU       84,F                  NINE TRACK TAPE OC3
DRMOO EQU       85,F                  DRUM 100
DSKOO EQU       86,F                  DISK DRIVE 200
DSK01 EQU       87,F                  DISK DRIVE 201
DSK02 EQU       88,F                  DISK DRIVE 202
DSK03 EQU       89,F                  DISK DRIVE 203
CRT70 EQU       90,F                  DISPLAY 270
DSK90 EQU       94,F                  DISK DRIVE 290
DSK91 EQU       95,F                  DISK DRIVE 291
DSK92 EQU       96,F                  DISK DRIVE 292
DSK93 EQU       97,F                  DISK DRIVE 293
*
*     FUNCTION DEFINITIONS
*
EXP   FUNCTION  RN1,C24               AN EXPONENTIAL FUNCTION
0     0    .1   .104 .2   .222 .3   .355 .4   .509 .5   .69
.6    .915 .7   1.2  .75  1.38 .8   1.6  .84  1.83 .88  2.12
.9    2.3  .92  2.52 .94  2.81 .95  2.99 .96  3.2  .97  3.5
.98   3.9  .99  4.6  .995 5.3  .998 6.2  .999 7    .9997 8
*
*     STORAGE DEFINITIONS
*
CORE  STORAGE   512                   CORE CONFIGURATION
INIT  STORAGE   2                     NUMBER OF INITIATORS
JOBQ  STORAGE   60                    MAXIMUM SIZE OF JOB QUEUE
PDSK  STORAGE   2                     NUMBER OF DISKS FOR JOBLIBS
RDR   STORAGE   1                     NUMBER OF INPUT READERS
SPOOL STORAGE   8000                  NUMBER OF TRACKS FOR SPOOLING
TAPE7 STORAGE   1                     NUMBER OF SEVEN TRACK TAPES
TAPE9 STORAGE   3                     NUMBER OF NINE TRACK TAPES
WTR   STORAGE   2                     NUMBER OF CLASS A OUTPUT WRITERS
*
*     VARIABLE DEFINITIONS
*
CHAP1 VARIABLE  P1*8+5                SELECT TO DISPATCH PRIORITY
CHAP2 VARIABLE  (PR-5)/8              DISPATCH TO SELECT PRIORITY
HOUR  VARIABLE  3600000               ONE HOUR IN MILLI-SECONDS
MIN   VARIABLE  60000                 ONE MINUTE IN MILLI-SECONDS
SEC   VARIABLE  1000                  ONE SECOND IN MILLI-SECONDS
READ  VARIABLE  P3*60                 TIME TO READ CARDS
SYSK  VARIABLE  136                   NUC + SQA + LPA + MASTER SCHED.
SYSIN VARIABLE  (P3/401+1)10          NUMBER OF INPUT SPOOLING TRACKS
SOUT  VARIABLE  P4/27+1+P8/42+1       NUMBER OF OUTPUT TRKS NEEDED
SOUTA VARIABLE  P4/27+1               NUMBER OF CLASS A OUTPUT TRKS
```

```
SOUTB VARIABLE   P8/42+1                 NUMBER OF CLASS B OUTPUT TRKS
WRITE VARIABLE   P4*50                   TIME TO PRINT
*
*     IPL SEQUENCE INCLUDING DELAY (THIRD PARAMETER) TO BUILD UP JOB
*     QUEUE BEFORE STARTING PROCESSING.
*
      GENERATE   ,,V$HOUR,1,127
      ENTER      CORE,V$SYSK
      ADVANCE                            LENGTH OF TIME TO IPL
      SPLIT      1,SPUN
*
*     LOOP TO START AND STOP READER AT APPROPRIATE TIME
*
SRDR  TEST L     S$JOBQ,10               MINIMUM JOB QUEUE SIZE
      ENTER      CORE,42                 REGION SIZE OF A READER
      SEIZE      RDR31
      ADVANCE                            TIME TO INITIALIZE READER
      LOGIC S    RDR31
      GATE SF    JCBQ
      LOGIC R    RDR31
      ADVANCE                            TIME TO TERMINATE READER
      RELEASE    RDR31
      LEAVE      CCRE,42
      TRANSFER   ,SRDR
*
*     LOOP TO START AND STOP PUNCH AT APPROPRIATE TIME
*
SPUN  TEST G     Q$PUN,20                SOUT B QUEUE SIZE TO START PUNCH
      ENTER      CORE,28                 REGION SIZE OF OUTPUT WRITER
      SEIZE      PUN32
      LOGIC S    PUN
      TEST E     Q$PUN,0
      LOGIC R    PUN
      RELEASE    PUN32
      LEAVE      CORE,28
      TRANSFER   ,SPUN
*
*     CLOCK WHICH DETERMINES THE LENGTH OF THE SIMULATION RUN
*
      GENERATE V$HOUR
      TERMINATE  1
*
*     JOB GENERATOR IS USED FOR TESTING PURPOSES ONLY
*
      GENERATE   60000,FN$EXP,,,124      JOB GENERATOR (TEST)
      ASSIGN     2,1                     NUMBER OF STEPS
      ASSIGN     3,100                   NUMBER OF CARDS
      ASSIGN     4,2500                  NUMBER OF LINES OF PRINT
```

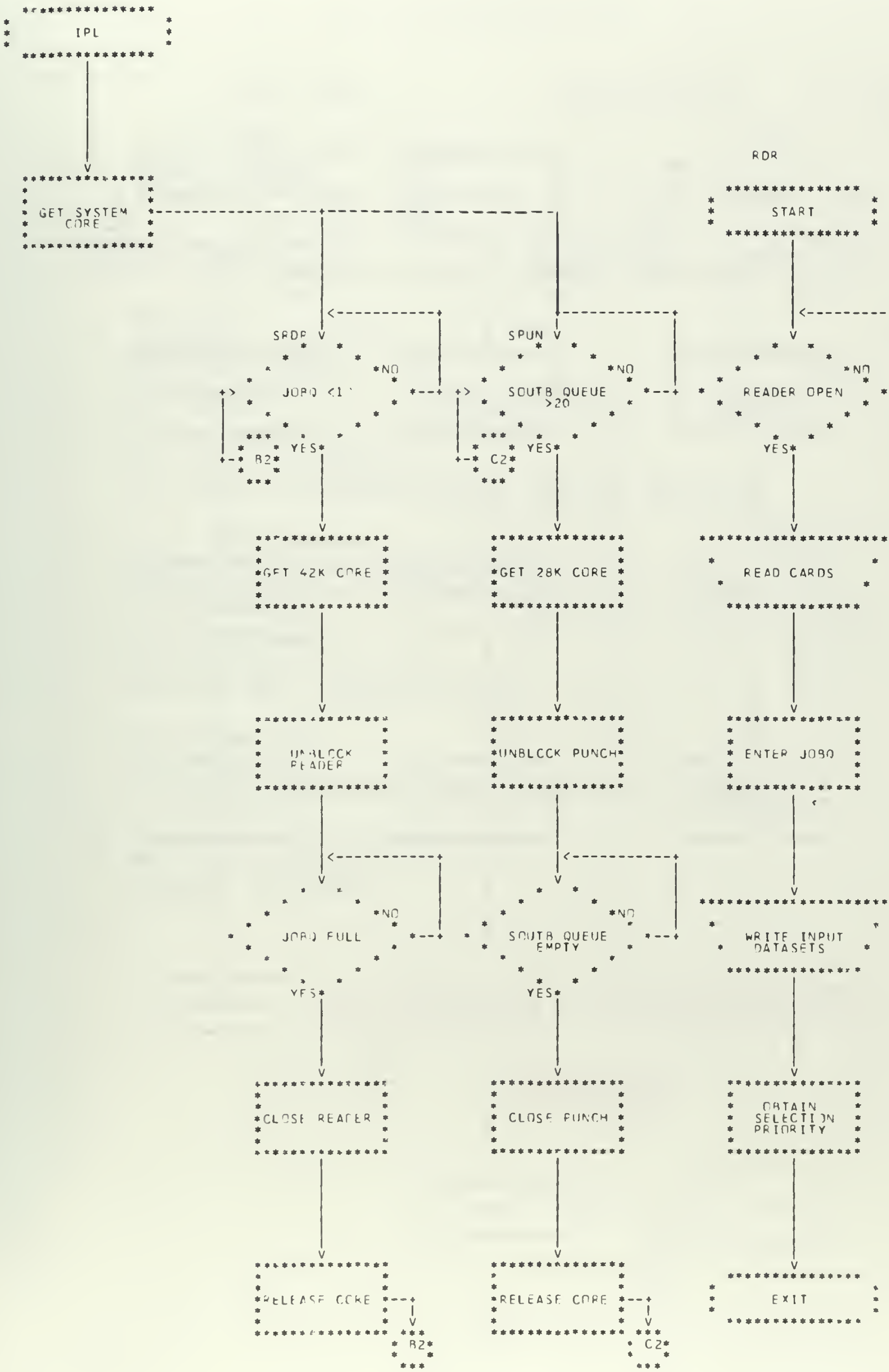
```
        ASSIGN      5,100                      REGION SIZE
        ASSIGN      6,30000                    EXECUTION TIME (CPU)
        ASSIGN      7,100                      MEAN TIME BETWEEN INTERRUPTS
        ASSIGN      8,10                       NUMBER OF CARDS PUNCHED
*
*      READER/INTERPRETER
*
        GATE LS     RDR31
        ENTER       RDR
        ENTER       JCBQ
        ENTER       SPOOL,V$SYSIN
        ASSIGN      1,8                        DEFAULT PRIORITY
        ADVANCE     V$READ
 LVRDR  LEAVE       RDR
        PRIORITY    P1,BUFFER
*
*      INITIATOR/TERMINATOR
*
        ENTER       INIT
        PRIORITY    125
        ENTER       CORE,58
*      LOCATE A FREE INITIATOR
        TRANSFER    ALL,,LAST,3
        SEIZE       INIT1
        ASSIGN      12,INIT1
        TRANSFER    ,JSTRT
        SEIZE       INIT2
        ASSIGN      12,INIT2
        TRANSFER    ,JSTRT
        SEIZE       INIT3
        ASSIGN      12,INIT3
        TRANSFER    ,JSTRT
        SEIZE       INIT4
        ASSIGN      12,INIT4
        TRANSFER    ,JSTRT
 LAST   SEIZE       INIT5
        ASSIGN      12,INIT5
*      JOBS START
 JSTRT  PREEMPT     CPU,PR
        ADVANCE                                TIME TO INITIATE JOB
        PRIORITY    V$CHAP1,BUFFER
        LEAVE       CORE,58
 ENQ    ADVANCE                                TIME TO ENQ
*      STEPS START
 SSTRT  RETURN      CPU
        ENTER       CORE,P5
 ALLOC  ENTER       SPOOL,V$SOUT
        TEST G      P6,0,DEALL                 DID JOB FAIL
```

```
       PREEMPT    CPU,PR
       ADVANCE                            TIME FOR ALLOCATION
BACK   SPLIT      1,SVC
       ADVANCE    P6
DEALL  LEAVE      SPOOL,V$SYSIN
       ADVANCE                            TIME TO TERMINATE JOB STEP
       LEAVE      CORE,P5
       LOOP       2,SSTRT
       ADVANCE                            TIME TO TERMINATE JOB
       RETURN     CPU
       PRIORITY   V$CHAP2
       RELEASE    P12
       LEAVE      INIT
       SPLIT      1,PUNCH
*
*      CLASS A CUTPUT WRITER
*
       ENTER      WTR
       ADVANCE    V$WRITE
       LEAVE      SPOOL,V$SOUTA
       LEAVE      JOBQ
       LEAVE      WTR
       TERMINATE
*
*      CLASS B CUTPUT WRITER
*
PUNCH  QUEUE      PUN
       GATE LS    PUN
       SEIZE      PUN
       ADVANCE                            TIME TO PUNCH CARDS
       LEAVE      SPOOL,V$SOUTB
       RELEASE    PUN
       DEPART     PUN
       TERMINATE
*
*      SVC INTERRUPTER
*
SVC    ADVANCE    P7                      TIME BEFORE INTERRUPT
       PRIORITY   125
       PREEMPT    CPU,PR,WAIT,6,RE
       ADVANCE                            PROCESSING TIME FOR SVC
       RETURN     CPU
       TERMINATE
*
*      WAIT STATE AREA
*
WAIT   ADVANCE    1000                    WAIT TIME
       PREEMPT    CPU,PR
```

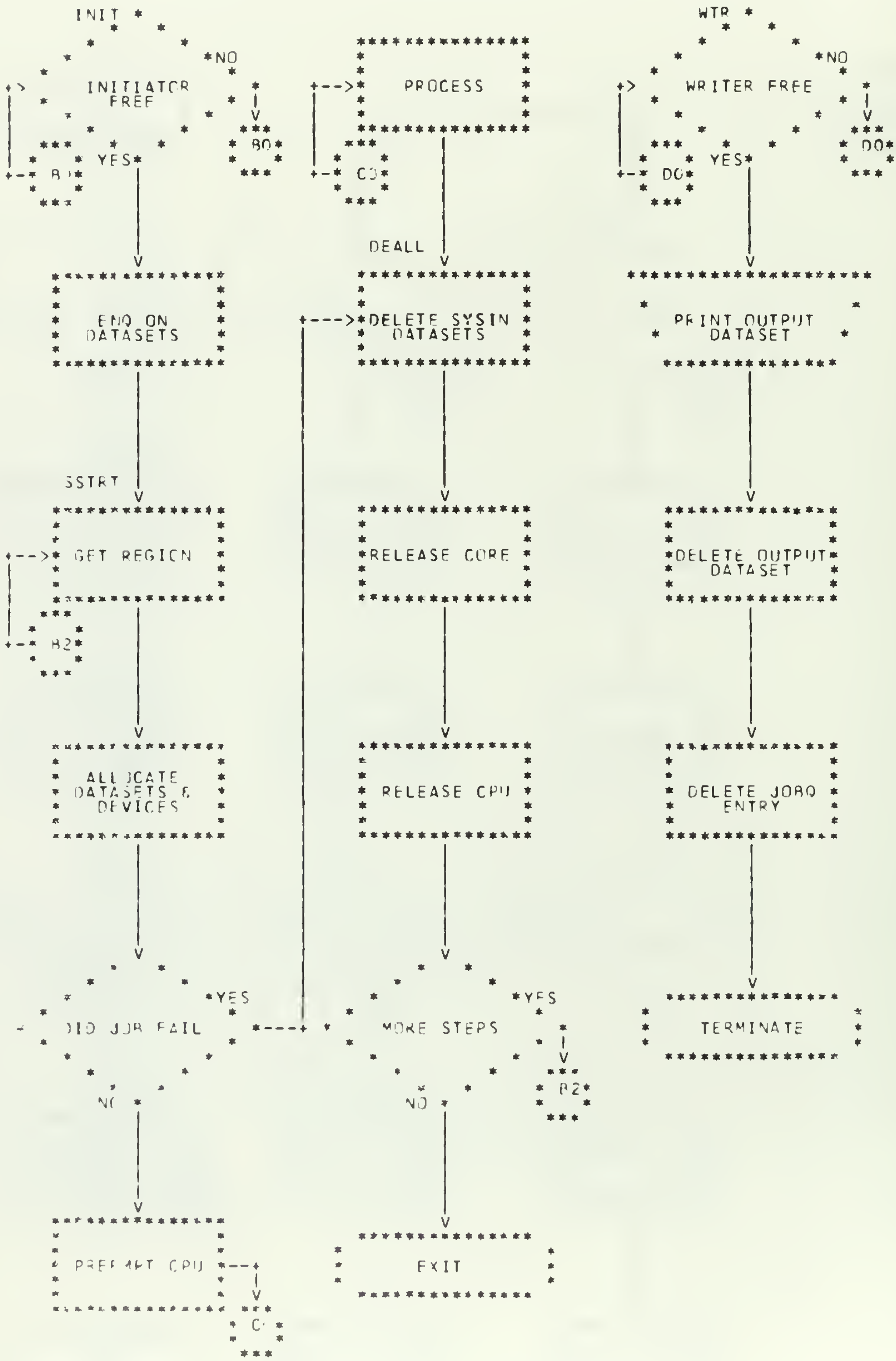
```
         TRANSFER    ,BACK
*
*       CONTROL SECTION FOR SIMULATION RUN
*       FIRST PARAMETER ON START CARDS IS NUMBER OF HOURS TO BE SIMULATED
*
         SIMULATE
         START       6,,3,1
         END
```

APPENDIX C

INITIAL PROGRAM LOAD READER/INTERPRETER



INITIATOR/TERMINATOR OUTPUT WRITERS



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13 ABSTRACT

This paper reports on the design of a computer simulation model written in GPSS. A brief description of the System/360 operating system is given. The model consists of macroscopic modules representing distinguishable computer tasks which are capable of independent operation and/or more detailed expansion. A pseudo jobstream of sufficient detail was used to test the viability of this model. Guidelines for experimentation (which was prohibited by a complete lack of data) are outlined; suggested uses of the model are given.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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Computer Modeling						
MVT Simulation						
Computer Simulation						